GENETIC STUDIES ON DIFFERENTIAL HOST REACTION TO PENICILLIUM SEEDLING DISEASE OF CORN

BY

EARL REECE LENG

B. S., University of Illinois, 1941

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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GENETIC STUDIES ON DIFFERENTIAL HOST REACTION TO PENICILLIUM SEEDLING DISEASE OF CORN

Despite the recognized importance of seedling diseases as factors injurious to the corn crop, little research has been devoted to breeding for resistance to such diseases. Even less attention has been given to fundamental genetic studies on differential host reaction to any of the more common seedling diseases. The objective of the studies reported in this paper was to investigate in some detail the hereditary mechanisms conditioning reaction of corn to the seedling disease caused by *Penicillium oxalicum* (Currie and Thom). Since there was little previous information regarding differential reaction to this disease, the main effort in the studies reported here was devoted to surveying in detail the reactions of a wide range of types of corn and of the F_1 croses between them. Only limited tests were conducted to determine the reactions of advanced generations and backcross progenies.

Materials and Methods

Sixty-six types of corn, 120 F_1 crosses between them, and approximately 70 advanced generation and backcross progenies and families were tested for their reaction to the disease. All tests were conducted by artificially inoculating seed to be tested with spores of the fungus. The fungus cultures used for these inoculations were derived from a strain of *P. oxalicum* isolated from corn ears in 1942, and selected for strong pathogenicity. Seed to be inoculated was first damaged on the crown with a sharp knife, to permit the fungus to become established.

The experiments reported were conducted in the winter and spring seasons of 1946-1947 and 1947-1948. Each

separate test was laid out as a randomized block experiment, and all tests were carried out in fumigated greenhouse sand benches. Samples were scored for reaction when uninoculated check plants were in the three-leaf stage of development. Reaction was scored on a "resistance index" scale, whose values per plant ranged from 5 (most resistant) to 1 (completely susceptible). Mean resistance index values were calculated for each sample, and all sets of data obtained were analyzed statistically by the analysis of variance procedure. In some cases, other methods of statistical analysis were also employed. These are discussed in greater detail in later portions of the paper.

Experimental Results

General Observations on Reaction:

Even in susceptible material, the disease appeared to cause only a slight reduction in initial emergence of seedlings. Susceptible reactions first became apparent in delay or failure of the first leaf to rupture the coleoptile. As a rule, when this leaf emerged, it was chlorotic, and it often showed blighting on its margins or tip. Susceptible plants remained badly stunted and retarded in development, and frequently were killed within a few days after emergence. Mesocotyls of susceptible plants seldom showed lesions, but rotting of seminal roots and of the scutellum was often observed.

Resistant plants remained nearly normal in color and general appearance, but were frequently stunted to some extent. In such plants, root rotting was seldom observed to any considerable degree, but rotting of the scutellum appeared to be fairly common.

Gradations in reaction between the extreme types described occurred commonly. Such gradations increased the difficulty of assessing resistance index values, particularly in segregating or variable material.

Reactions of Parental Types:

Wide differences in reaction to the disease were observed between the parental types tested. Reactions ranged from a high degree of resistance to virtually complete susceptibility. Although reactions of the various parental types varied to some extent from test to test, there was a highly significant correlation between the resistance index values of types when tested in two to four separate experiments.

Of the parental types tested in several different experiments, the dent inbred line 90 and the sweet corn strain 6-355 were outstanding in resistance to the disease. The strain 6-7 (derived from Illinois High Protein) showed nearly complete susceptibility in all tests in which it was included. The widely-used dent inbred lines WF9, Os420, and L289 also showed marked susceptibility in nearly all tests. Few of the most commonly used dent inbred lines exhibited a satisfactory degree of resistance.

Relation of Endosperm Characteristics to Reaction:

Evidence from the behavior of reciprocal crosses and from other experiments suggested that the endosperm of the seed might play an important part in conditioning reaction to this and other seedling diseases. However, tests of a number of stocks gave no indication of association between common endosperm characteristics and reaction to the disease. Types of corn homozygous for sugary endosperm (su_1) varied in reaction from high resistance to marked susceptibility. Similar differences were observed between types homozygous for starchy or floury endosperm. A flint stock and a flour stock, virtually isogenic for other characteristics, were almost identical in reaction. Tests of stocks homozygous for non-wrinkled sugary endosperm (su_2) and for waxy endosperm (wx) showed a similar lack of association between these endosperm characteristics and reaction to the disease.

Kernels from ears segregating for white vs. yellow endosperm color were separated according to color and tested for reaction to *P. oxalicum*. No evidence was found of association between endosperm color and reaction. Tests of kernels segregating for endosperm color were carried out in stocks homozygous for su_2 and also in dent stocks. Results were essentially identical in both sets.

Variations in Reaction Within Inbred Lines:

Certain inbred lines, selfed for twenty or more generations, were frequently somewhat variable in their reaction to the disease. In an attempt to gain further information on the causes of this variability, two of these lines were subjected to detailed tests.

Individual selfed ears of inbred 90 (resistant) were tested separately in 1947, and marked differences in reaction were observed between them. Tests of progeny from these same ears in 1948 indicated that these differences were the result of environmental influences. There was some indication that immaturity of seed lowered resistance to the disease. No indications were found of heritable variations within the inbred line.

A similar test of individual selfed ears of inbred L289 (susceptible) showed no significant differences in reaction between them. Progeny tests of these ears were not conducted, since there was no evidence of consistent variations in reaction within the line.

Reactions of F_1 Crosses:

As the first step in the genetic analysis of reaction to the disease, F_1 crosses between a number of the parental types previously studied were tested for reaction. In all tests of F_1 material, the respective parental types were also included, to permit direct comparisons of parental and F_1 resistance index values.

Consistent differences between reciprocal crosses in reaction to the disease were observed. In nearly all crosses,

the female parent appeared to have a greater influence on F_1 reaction than the male parent. Analysis of data from a systematic set of reciprocal crosses between nine inbred lines showed a correlation of +. 701 (highly significant) between the reactions of all crosses and those of their respective female parents. The value of the coefficient of correlation between the reactions of the same crosses and those of their male parents was +. 227 (not significant at the 5 per cent level).

From the results of tests of parental types and F_1's, reaction to *P. oxalicum* appeared to be a highly heritable character. In two different sets of single crosses, heritability of reaction was estimated by regression analysis at 60 to 75 per cent or higher. There was a definite tendency for resistance to be at least partially dominant to susceptibility. There was also some evidence of non-allelic gene interaction. Dominance relationships were to some extent obscured by an apparent association between hybrid vigor and resistance. This association was particularly obvious in crosses between susceptible strains.

Analysis of data by the constant-parent regression method indicated that certain inbred lines might be more efficient than others as testers of reaction to the disease. In several cases, lines were more efficient as testers when used as male parents than when used as female parents. There appeared to be no consistent relationship between the reaction of any given inbred line and its efficiency as a tester.

Reactions of Advanced Generations:

Variations within parental types and F_1 populations, as well as difficulties in classification, made it impossible to construct valid segregation ratios from tests of the reactions of F_2 and backcross populations. Limited information from such tests indicated, however, that two resistant stocks carried substantially the same factors for resistance to the disease. Tests of F_2 progeny from a cross between two susceptible inbred lines indicated that these lines were

probably very similar in their genetic composition controlling reaction.

F_2 populations from several crosses between resistant and susceptible types were tested. Results were not conclusive, but as a rule, F_2 reaction was intermediate between reactions of the two parents. In several cases, partial dominance of resistance over susceptibility was indicated by a tendency for F_2 reaction to be closer to that of the more resistant parent.

Tests of fifty F_3 families from the cross 90 (resistant) x Os420 (susceptible) gave some indication that inheritance of reaction to the disease might be multifactorial in nature. A tendency toward partial dominance of resistance was also indicated by these tests. A few families were substantially as resistant as inbred 90, and two families were nearly as susceptible as inbred Os420. There was some indication of a linkage between kernel-row number and reaction. All the most resistant families were produced on F_2 ears with a high row number, similar to that of inbred 90, while the most susceptible families were produced on F_2 ears with 12 or 14 rows (the typical number of inbred Os420).

Discussions and Conclusions

From evidence presented, it was concluded that reaction to *Penicillium oxalicum* seedling disease is genetically controlled, and that the degree of heritability of this character is high. There were definite indications that reaction is associated with some unidentified characteristic or set of characteristics of the endosperm. Resistance appeared in most cases to be at least partially dominant over susceptibility. There was some evidence that inheritance of reaction is multifactorial in nature, but other evidence indicated that the number of genes involved might not be large. It was suggested that studies of the nature of resistance to the disease might provide more critical information and more effective methods for analyzing the inheritance of reaction. A plan for such studies was outlined briefly.

VITA

The author was born on a farm near Williamsfield, Knox County, Illinois, on June 12, 1921. He attended the public schools of his home community, graduating from the Williamsfield Community High School in May, 1937. He then matriculated in the College of Agriculture, University of Illinois. He received the degree of Bachelor of Science in Agriculture from that institution in June, 1941. The degree was conferred with Highest Honors, and the author was named valedictorian of his class.

He was appointed Special Research Assistant in Plant Genetics in the Department of Agronomy, Illinois Agricultural Experiment Station, in 1941, being associated with the corn breeding project of the station. In April, 1942, he resigned this position to enter the Army of the United States, where he served as an officer until being separated from the service in January, 1946.

In February, 1946, he returned to the University of Illinois to continue his graduate studies, and was awarded the degree of Master of Science in Agronomy in June of that year. From September, 1946, until February, 1948, he again held the position of Assistant in Plant Genetics in the Illinois Agricultural Experiment Station.

He is a member of the American Society of Agronomy, the Genetics Society of America, the American Association for the Advancement of Science, Gamma Sigma Delta, Phi Kappa Phi, Alpha Zeta, and Sigma Xi, and is also a Charter Associate of the Arctic Institute of North America.

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